Original Article / Özgün Araştırma

Effect of Non-cadaveric Methods on the Anatomy Education of Medical Students

Kadavra Dışı Yöntemlerin Tıp Öğrencilerinin Anatomi Eğitimine Etkisi

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Keywords
3D Human Anatomy Application, human anatomy, anatomy education, human anatomy models, medical education

Anahtar Kelimeler
3D İnsan Anatomi Uygulaması, insan anatomisi, anatomi eğitimi, insan anatomisi modelleri, tıp eğitimi

Received/Geliş Tarihi : 20.01.2021
Accepted/Kabul Tarihi : 05.02.2021

doi:10.4274/meandros.galenos.2021.99815

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Abstract

Objective: Recently, with the inability to conduct face-to-face training due to the increasing cases of pandemic diseases such as the coronavirus disease-2019, the importance of digital applications in practical anatomy education has increased. This study aimed to compare cadaveric and non-cadaveric examination methods to evaluate the benefits of innovative models for education.

Materials and Methods: A total of 120 second-year medical student volunteers who had never used the three-dimensional (3D) Human Anatomy Application participated in the study. They were asked to fill out a questionnaire containing their opinions about the anatomy lesson. Then, the students were randomly divided into three groups according to their learning methods.

Results: Among the participants, 75.9% stated that working on the model was sufficient and 36.7% mostly used the printed human anatomy atlas when studying for practical lesson. While the success rates of different modules were similar in the practice groups, in the same module, the success of the 3D Human Anatomy Application group was higher than that of other practice groups.

Conclusion: Although they had not used it before, students who received training with the 3D Human Anatomy Application were more successful than the other groups. 3D applications developed in recent years have offered a new perspective to anatomy education by creating a sense of reality without touching it and allow formations and examinations from all angles. With the emergence of pandemic diseases, 3D applications will gain more importance as the future of anatomy education.

Öz

Amaç: Son yıllarda koronavirüs hastalığı-2019 gibi pandemik hastalıkların artmasıyla yüz yüze eğitimin yapılamaması anatomi uygulama eğitiminde dijital uygulamaların önemini artırmıştır. Gelişen teknolojinin yarattığı yenilikçi modellerin eğitime sağladığı yararları değerlendirmek için kadavra dışında kullandığımız yöntemleri kıyaslamak istedik.

Gereç ve Yöntemler: Çalışmamıza üç boyutlu (3D) İnsan Anatomisi Uygulaması'nı hiç kullanmayan 120 ikinci sınıf tıp öğrencisi gönüllü katıldı. Öğrencilerden anatomi dersi ile ilgili görüşlerini içeren bir anket doldurmaları istendi. Daha sonra öğrenciler öğrenme yöntemlerine göre rastgele üç gruba ayrıldı.

Bulgular: Anket sonucunda öğrencilerin %75,9'u maket üzerinde çalışmanın yeterli olduğunu, %36,7'si uygulama dersi için çalışırken en çok basılı insan anatomisi atlasını kullandığını belirtmiştir. Test sonucunda ise uygulama gruplarında farklı

ders kurulları arasında başarı benzerken, aynı ders kurulunda 3D İnsan Anatomisi Uygulama grubunun başarısı diğer uygulama gruplarına göre daha yüksekti.
Sonuç: Daha önce kullanmadıkları halde 3D İnsan Anatomisi Uygulaması ile eğitim alan öğrenciler diğer gruplara göre daha başarılı oldular. Son yıllarda gelişen 3D anatomi uygulamaları, dokunmadan gerçeklik hissi yaratarak ve oluşumların tüm açılardan incelenmesine olanak sağlayarak anatomi eğitimine yeni bir bakış açısı sunmuştur. Artan pandemik hastalıklar nedeniyle anatomi eğitiminin geleceğinde daha fazla önem kazanacağını düşünüyoruz.

Introduction

Human anatomy, which is the most important component of medical education, is the branch of science that examines the normal shape and structure of the body, the organs that make up the body and the relationships between them. Anatomy, which is taught theoretically and practically to students in the first years of medical school, is the cornerstone of medical education (1-3). In order for the students to learn the human body comprehensively, to train them more efficiently and to interpret the diagnosis and treatment of diseases clinically, the anatomy education should also be done practically. While seeing the structure of the human body during practical training allows them to learn in detail, their confrontation with the phenomenon of death contributes to the formation of a physician identity (4-6).

It is widely accepted that the ideal method for students to learn and understand human anatomy should be practical training as well as theory. Dissection has been the cornerstone of practical anatomy education for over 400 years (7,8). The dissection of human cadavers enables the person to be prepared for death, active and deep learning, to develop manual skills, and to understand the relationship between the symptoms and pathology of diseases (9-11). In addition, it teaches students to be respectful and attentive to the cadaver, and gives students an important ethical awareness in their approach to their patients in the future (4).

Today the resources for the cadaver need are the orphans, body donation and the import of cadavers from other countries, all arranged with legal regulations (12). There are countries in the world that provide the majority of cadavers through donations (13,14). However, for African countries Ethiopia, Kenya, Ghana and Nigeria, Asian countries Turkey, India, Indonesia, Iran, Saudi Arabia, Singapore, Bangladesh, European countries Bulgaria, Greece, Italy, Romania, Serbia, North American country Mexico, South American countries Argentina, Brazil, Colombia and Paraguay, the supply of cadaver is often from orphans and there is need for more donations (13).

Difficulties in obtaining cadavers worldwide limit their use in education. While countries such as Malaysia, Saudi Arabia, and Singapore try to get their cadavers from foreign countries because of the low amount of donations (15-17); donation in China is quite high, however still insufficient for the density of students (18,19). In our country, insufficient donation and high cost of imported material are the biggest obstacles in meeting the cadaver need (20).

The applications to the dead human body trigger the objection bacause of the social and traditional structure, morality and religion. Therefore, the relevant provisions of the laws allow the body to be used in scientific research after death and to protect it from all kinds of malicious situations. According to the regulated laws [Article 14 (6) Law on Organ and Tissue Collection, Preservation and Transplantation Dated 1979 Numbered 2238], a person can donate his body as a cadaver with his will or with the approval of his relatives after death (21,22). In our country, efforts are made to raise public awareness by informing about the protection of donation by laws and how important the benefits it will bring to science are (18,21,23,24).

For anatomy education, the average number of students per cadaver should be between 4-12. It has been reported that our country has an average above this number and that there are no cadavers in some universities that teach anatomy (21). Apart from the difficulties of supplying cadavers in universities, there are also problems such as suitability of dissection laboratories (space and ventilation problems suitable for the number of people) and high costs associated with their maintenance and inadequate number of cadavers compared to the increasing number of students in most medical schools. In addition, with cadaver dissection in which students actively participate, education takes a long time;

also, inaccessibility to some body parts, change and destruction of the organs and tissues of the cadaver in time and the negative effects of exposure to formaldehyde smoke may impair the quality of education (25-28). By saying that "to obtain a true and perfect knowledge of which (some few veins) I have dissected more than ten human bodies", Leonardo da Vinci emphasized that understanding the human body by dissection requires intense effort (29). The increasing number of pandemic diseases in recent years, make cadaver training impossible (30,31). Pather et al. (32) also stated that after the coronavirus disease-2019 (COVID-19) epidemic, anatomy education stepped into an unknown future. These reasons led anatomists to seek new educational tools (33).

Developing technology creates new opportunities in education as well as in many other fields. In recent years, the use of some technological materials in anatomy education has increased significantly. The main purpose of alternative learning tools developed in this area is to avoid the negative aspects of cadaver education and to create materials close to it (34,35). Today's innovative digital technologies increase the effectiveness of anatomy learning by using lternative learning strategies and alternative education tools. Anatomy models and three dimensional (3D) Anatomy Apps developed each day are among the frequently used educational tools. Increased and visually enriched printed anatomy atlases also support education and learning (35,36). Plastination, use of 3D printed models and teaching of living and radiologic anatomy are among the other methods used in anatomy education (37).

In our faculty, combined education is given on human models and cadavers. Students, as extracurricular materials, use printed atlases and 3D Human Anatomy App in our university database. We wanted to investigate the effect of these methods, which we use as an alternative to cadavers, on learning.

Materials and Methods

Medical faculty students studying intensive anatomy at Aydın Adnan Menderes University were included in the study. The study was carried out with the participation of 120 volunteers (62 males, 58 females) from students who took a musculoskeletal system course in the first year of their education, passed the theoretical and practical exams and who have never used 3D Human Anatomy Apps in our university's database.

At the beginning of the school year, a questionnaire consisting of 5 questions was applied to the participants to evaluate their opinions about the anatomy lesson. While the students were only asked to indicate their age and sex in the content of the questionnaire, the students were not asked to write their names and surnames for the reliability of the answers. The following questions were asked: "Do you enjoy studying anatomy?", "Do you think it is sufficient to work on human models in anatomy practical lessons?", "Do you find the duration of anatomy practical lesson sufficient?", "Do you think that learning would be insufficient if cadavers were not used in anatomy practical lessons?" and "List the resources you used while studying anatomy lesson, from most to least (maximum: 1, medium: 2, minimum: 3)". In the answer to first four questions; a 5-point Likert-type scale consisting of "always", "mostly", "not sure", "occasionally", "never" was used and for the last question resources to be considered were listed as "Course Notes", "Human Models", Human Anatomy Atlases.

From anatomy practical education models used by students, current atlases (Human Anatomy Atlas), models in the practice hall of our university (Human Anatomy Models) and 3D digital visual anatomy program in the database (3D Human Anatomy Apps) were selected (Figure 1A). According to these educational models, students were randomly and equally distributed to 3 groups named as Human Anatomy Atlas group (AG), Human Anatomy Models group (MG) and 3D Human Anatomy App group (3DG).

Three modules were selected for our research, in which the practical education was very intensive. Among these, cranial nerve and peripheral nervous system anatomy from neuroanatomy, heart anatomy from the cardiovascular system, and stomach, small and large intestine anatomy from the digestive system were evaluated. First, the students were given a theoretical lesson on the subjects, and then a practical lesson was given according to their groups.

At the end of the lecture, 25 structures were randomly selected from each of the regions described. The first form containing a name table by encoding

the anatomical structures with letters, an empty answer table by encoding the same by numbers was distributed to the students (Figure 1B). Students were given the second form containing questions on the subject of the visuals of these selected anatomical structures, and they were asked to fill in the letters corresponding to the asked structures in the answer table (Figure 1C). Ten minutes were defined for each table containing 25 questions. Each question was evaluated as 4 points and the success scores of the students were calculated over 100. The whole study process is defined in Figure 2.

Statistical Analysis

The scores were transferred to SPSS for Windows release 11.0 for statistical analysis. Minimum, maximum, mean and standard deviation values of the data were determined and compared with practical education models and modules by One-Way ANOVA test. Statistical significance was considered $p<0.05$.

Results

In our study, the participating students were 20-22 years old; 62 (51.6%) were males and 58 (48.4%) were females. The results of the questionnaire are given in Figure 3.

In our study, the answers of the students were evaluated and the mean, standard deviation, minimum and maximum values according to the subjects and groups are given in Table 1.

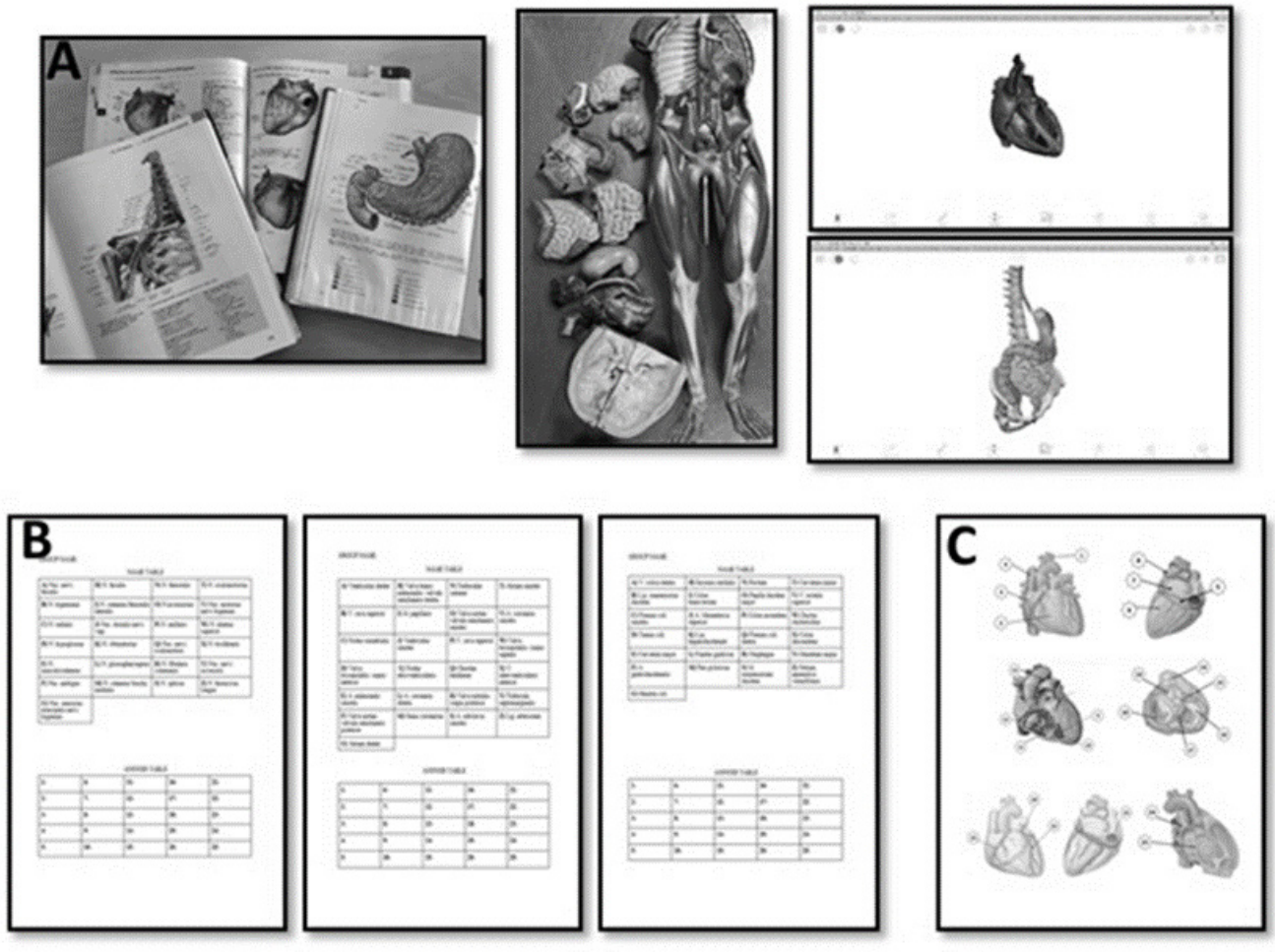

Figure 1. Educational materials used ve the first and the second form used for assessment

A: Educational materials used, B: The first form containing the name table and the answer table, C: The second form containing example of questions on heart anatomy

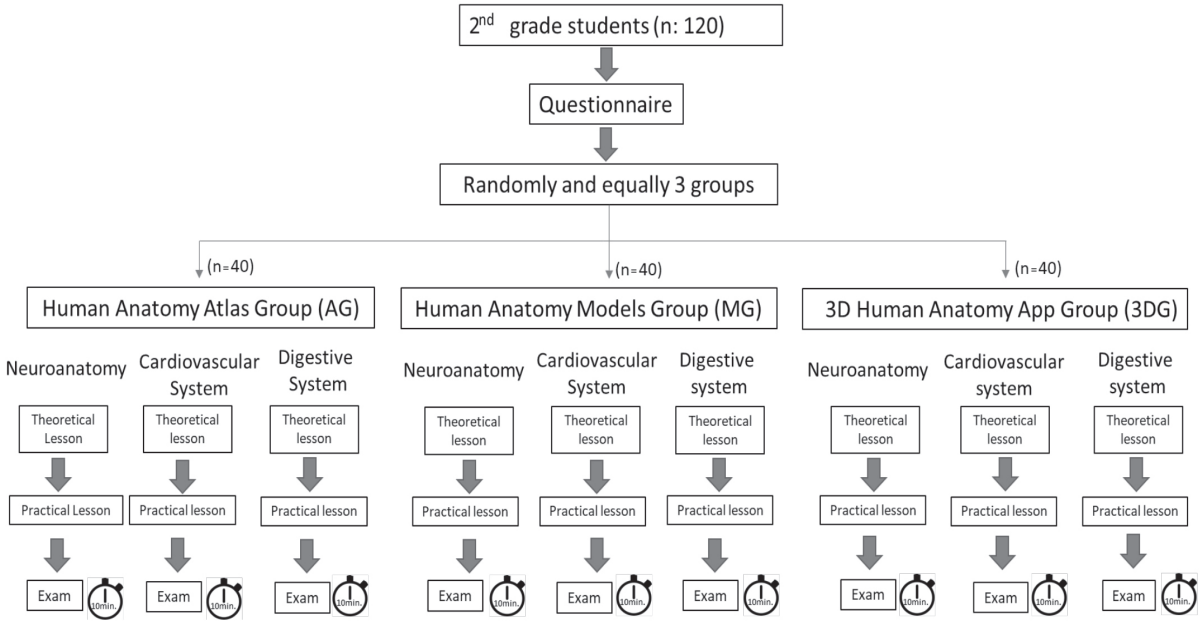

Figure 2. Schematic illustration of the grouping and assessment

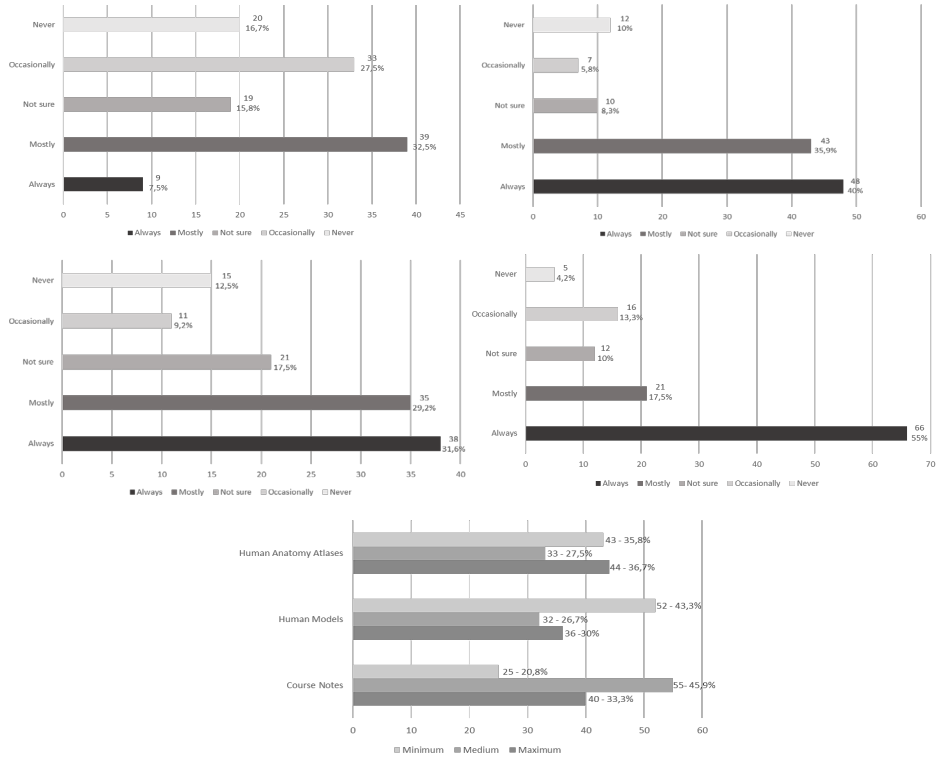

Figure 3. Outcomes of the questionnaire

A: Do you enjoy studying anatomy? B: Do you think it is sufficient to work on a human model in anatomy practical lessons? C: Do you find the duration of anatomy practical lesson sufficient? D: Do you think that learning would be insufficient if cadavers were not used in anatomy practical lessons? E: List the resources you used while studying the anatomy lesson from the most to the least

As a result of the variance analysis in Table 2, statistically significant differences were calculated as F=5.841, F=8.782 and F=6.856 (p<0.05). To test the source of the difference, the Tukey test was used because all of the post-hoc tests showed a homogeneous distribution. For all courses, with 3DG the direction of difference is between both AG and MG. There is no difference between AG and MG. 3DG is more successful in all lessons than other groups.

As a result of the variance analysis in Table 3, there is no statistically significant difference F=0.420, F=1.035 and F=1.293 (p>0.05). The modules we evaluated for the three training groups we formed did not differ significantly in terms of mean success scores

Table 1. Mean, standard deviation, minimum and maximum values of the exam according to modules and groups

Groups	Neuroanatomy		Cardiovascular system		Digestive system	
	Min-max	Mean ± SD	Min-max	Mean ± SD	Min-max	Mean ± SD
AG	56-88	73.5±10.78	52-96	69.5±12.54	52-96	71.4±13.81
MG	52-92	73.6±11.08	52-88	69.6±11.64	52-92	69.8±14.37
3DG	60-100	80.9±11.43	64-100	78.7±9.29	64-100	80.0±11.60

AG: Human Anatomy Atlas group, MG: Human Anatomy Models group, 3DG: 3D Human Anatomy App group, SD: Standard deviation, min: Minimum, max: Maximum

Table 2. Distribution showing the comparison of One-Way ANOVA test for practice groups according to modules

Module	Group	N	X	SD	F	P	Direction of the difference
Neuroanatomy	AG	40	73.5	10.78	5.841	0.004	Between 3DG and both MG and AG
	MG	40	73.6	11.08			
	3DG	40	80.9	11.43			
Cardiovascular system	AG	40	69.5	12.54	8.782	0.000	Between 3DG and both MG and AG
	MG	40	69.6	11.64			
	3DG	40	78.7	9.29			
Digestive system	AG	40	71.4	13.81	6.856	0.002	Between 3DG and both MG and AG
	MG	40	69.8	14.37			
	3DG	40	80.0	11.60			

AG: Human Anatomy Atlas group, MG: Human Anatomy Models group, 3DG: 3D Human Anatomy App group

Table 3. Distribution showing the comparison of One-Way ANOVA test for the modules according to the practise groups

Group	Module	N	X	SD	F	p	Direction of the difference
AG	Neuroanatomy	40	73.5	10.78	1.035	0.359	-
	Cardiovascular system	40	69.5	12.54			
	Digestive system	40	71.4	13.81			
MG	Neuroanatomy	40	73.6	11.08	1.293	0.278	-
	Cardiovascular system	40	69.6	11.64			
	Digestive system	40	69.8	14.37			
3DG	Neuroanatomy	40	80.9	11.43	0.420	0.658	-
	Cardiovascular system	40	78.7	9.29			
	Digestive system	40	80.0	11.60			

AG: Human Anatomy Atlas group, MG: Human Anatomy Models group, 3DG: 3D Human Anatomy App group, SD: Standard deviation

among each other. But in all of them, 3DG's mean score was the highest.

Discussion

Although the cadaver is an indispensable educational material that gives students experience by reaching the secrets of the body, its use in education has become difficult due to its serious disadvantages (cost, time-consuming, supply difficulties, etc.). Thus, developing technology with the advantages it provides, has made us question use of it in anatomy education (7,28). In some medical faculties in United States, programs that display the 3D human body in virtual reality to the finest detail, medical images such as ultrasound and computed tomography (CT), and educational models using human models are used (38). While interactive 3D anatomy software in anatomy classes is used at Iowa Carver College of Medicine, (36) The Ohio State University College of Medicine has started to use ultrasound as an innovative strategy in its education curriculum (39). Some authors reported the disadvantages of cadaverless anatomy education such as being difficult for students to develop depth perception in a virtual body, missing the opportunity to see natural anatomical variations of the body. Not working in the human body would create a deficiency in forming a medical identity, and would cause losing the consciousness of encountering with death (4,11,38).

In a study conducted in Canada (40), 93 medical students were divided into two groups. The groups received 15 hours of muscle practice training, the first group on a cadaver already dissected and prepared, the second group by dissecting the cadaver themselves. In the subsequent examination, no difference was noted in terms of success between the groups.

In a study investigating medical students' anatomy education's efficiency in using 3D printed models of skull (41), they concluded that the group of students working using this model was more successful in exams than those using atlas and cadaveric skulls. In a study (42) in which 52 students participated in Monash University, a pre-test including questions on the subject was applied to the students before the cardiovascular system practical training. Later, students were randomly distributed to three groups according to the educational materials, which are cadavers, 3D printing and a combination of the two and were given practical training and a post-test. Post-test scores were found to be significantly higher in the 3D printing group compared to other groups. In the study, the students who use this method emphasized that they had an advantage of particularly the structures being colored compared to cadavers. Curtin University has investigated the use of 3D printing models in anatomy education (43). Twenty-three students were divided into three education groups: 3D printing models, cadavers, and plastinated. An anatomy test and a questionnaire were conducted on the structures studied. 85% of the students reached correct answers for 3D printing models compared to other groups. 74% stated that the most useful method for learning structures is 3D models. They emphasized that three-dimensional printing models have high potential in facilitating anatomy learning.

In the study conducted at Health Sciences at Curtin University (44), Anatomage table, which presents a cadaver in a virtual scale on a table-sized iPad type screen, was used in practical lessons and then students were asked to evaluate. In the questionnaire conducted with the participation of 326 students, 79.5% found it useful in showing the size and neighbourhood of the organs and 56.7% emphasized that the structures could not be understood due to software errors in this method and poor image quality in some regions. Ludwig-Maximillian's University (45) divided the students who had previously studied anatomy into three groups using the Magic Mirror, Anatomage table and radiology atlases to investigate the learning effects provided by different systems. All three groups were evaluated with a pre-test and post-test consisting of multiple-choice questions. While there was an increase in the post-test scores of the groups using Magic Mirror and radiology atlases compared to the pre-test, no increase was observed in the test scores for the Anatomage Table group. Researchers have pointed out that the Magic Mirror system is important for learning compared to built-in anatomy learning tools.

In a study (46), the faculty created the Human Anatomy Education Page on Facebook, the social media site most frequently visited by University of Sharjah students, and researched how they could carry anatomy education beyond traditional methods. This page has been included in the educational resources of medical students for two academic years.

Most students agreed that the page was effective in contributing to learning and that Facebook could be a suitable learning environment. In this way, they stated that the education-oriented Facebook pages will lead many new technological ideas with increasing learning, ease of use, fast accessibility and low cost.

There are some studies stating that the use of ultrasound, a method that allows real-time visualization of anatomical structures and their relationships, has the potential to provide pre-clinical training in physical diagnosis (47). In the study conducted at the University of Pittsburgh School of Medicine, most students stated that this technology is very positive for anatomy education. They stated that although there are problems with the integration of ultrasonography (USG) into anatomy education, these can be easily overcome. Students "willingness to learn and anatomists" desire to teach with USG has led to the widespread application of ultrasound-based teaching initiatives in medical schools around the world (48).

When a survey of the University of Sydney medical school graduates (49) revealed students' dissatisfaction with their anatomy education, medical imaging was integrated into the anatomy curriculum. Three separate ultrasound training courses covering abdominal, pelvic and vascular anatomy were included in the practice of students taking anatomy lessons in three years. When asked for their opinions, more than 90% of the students stated that they were satisfied with their anatomy education with ultrasound, and more than 75% stated that they understood the abdominal anatomy better with ultrasound.

In a study at the University of Melbourne (50), when a transthoracic echocardiography module was added to the anatomy curriculum of medical students, 90% of the students stated that this method made anatomical structures easily visible, 83% stated that it reinforced learning and 83% requested that this method should consistently be used.

Research conducted at The Stanford University Division of Clinical Anatomy (51) found that cadaveric anatomy education's being supported by a wide variety of tools such as photos, videos and 3D models, while simplifying anatomy, actually also involve problems because of limited use and distribution. However, they stated that photogrammetry, used to create digital 3D models, tries to overcome such deficiencies by creating digital models from cadaver samples. In their study, they produced digital 3D models of 8 different regions from cadaver samples using photogrammetry. The faculty lecturers of the Stanford University Department of Clinical Anatomy stated that these models represented the original examples in a real way so their teaching capasity might be much higher. In the study, they emphasized that photogrammetry will have an important place in anatomy education in terms of transforming the cadaver into effective 3D models and providing more visual information compared to many other materials.

In our study, where we evaluated the methods, we used other than cadavers, the students studying by using 3D Human Anatomy Apps were more successful and were satisfied with the contribution of this method which they never used before, in learning and they stated that they would prefer it as a resource. Although the digital education materials used in our studies and in other studies are different from each other, it is seen that they are adopted by the students because they create a sense of reality close to the cadaver and increase the success. Thus, we think that education models developed using technology should be made cheap and easy to use and thus popularized.

The reliability and validity of the questionnaires conducted to evaluate the education offered to students, is high. Objective evaluation of the education received by students at regular intervals allows to increase the quality of the education offered, to eliminate the deficiencies and to develop new methods. Therefore, student feedback is important in order to achieve the targeted goals of anatomy practical education (52,53).

In a study (54) evaluating the views of the students (n=79) about anatomy education, 68.4% of the students stated that working on models in practical lessons was quite effective in learning anatomy and 70.8% of them stated that the time allocated to education on the model was insufficient. In another study (n=176), 92.1% of the students stated that it was necessary to use auxiliary lesson tools other than cadavers in anatomy practical lessons and when asked about the preferences of the students in the use of cadavers and human models, it was seen that 68.1% chose both. In a study in which 34 students participated in a medical school (55), a questionnaire was conducted to evaluate the students' opinions

about their learning by using the mobile augmented reality method in their practical anatomy education. The students emphasized that learning with mobile augmented reality adds a sense of reality, increases the interest in the lesson by embodying the relevant subject and stated that providing a flexible learning environment, it is useful in their individual work and such applications should be expanded. In another study (56), in a survey of 430 students from medical and health sciences, the majority of students found it necessary to include anatomical structures created using 3D printing technology in education. In these studies, it is seen that students adopt more the newly created methods.

In our questionnaire study, 40% of the students stated that they enjoyed studying anatomy, 75.9% of the students stated that it was sufficient to work on the model, 60.8% stated that the practice lesson time was sufficient and 72.5% of them said that learning would be insufficient if cadavers were not used in practical lessons, 36.7% stated that they mostly used the printed human anatomy atlas while studying for the practice lesson. However, it was observed that the students who used the 3D app in our practical training increased their success and so more adopted this method. Evaluating practical training with different materials in all subjects of anatomy will increase the success.

Conclusion

It is essential for students to understand the human body in order to be a well-equipped physician with a holistic approach. For this, practice in medical education is essential. 3D anatomy applications, one of the methods used outside cadaver in recent years, are new to anatomy education in terms of examining the structures from all angles, ending learning anatomy in a static or in-place form like a cadaver, showing the anatomical changes in a living organism functionally and visually increasing the permanence of learning. Offered a point of view. In our study, we found that this method increases the success of students. Nowadays, due to pandemic diseases, the importance of 3D Human Anatomy Apps, which provide a flexible and individual learning environment for remote anatomy practical training, has increased. For this reason, we believe that these educational models developed by using technology should be widely used, developed, cheapened, easily accessible, and should be a part of education life.

Acknowledgements: We would like to thank to Gizem Sakallı, PhD student, for her contribution to data collection.

Ethics

Ethics Committee Approval: Ethics committee approval is not required for the study.

Informed Consent: Patient consent is not required.

Peer-review: Externally peer-reviewed.

Financial Disclosure: The authors declared that this study received no financial support.

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